Low Energy Detector Response Calibration for the Sudbury Neutrino Observatory

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A significant background systematic to SNO's NC paper [1] was the Čerenkov tail, and the uncertainty in our determination of the Čerenkov tail from the low energy events in the detector. These events are due to the very large number of low energy events in the detector that are reconstructed into our fiducial volume and energy window due to finite detector resolution and imperfect detector response. The analysis of these events with our existing calibration sources is complicated because these sources have emissions with high enough energy to photodisintegrate the deuteron producing neutrons in the D_2O . These neutrons subsequently capture and produce high energy gamma rays. In this manner a 2.2 MeV gamma ray background can be transformed into a 6 MeV signal. To avoid the complications of tracking both a real and photodisintegration components of the calibration sources, we developed an alternative sub-photodisintegration-threshold gamma ray source.

The ^{88}Y source is a simple low energy gamma ray source. It has a 106.65 day half-life, and emits two dominant gamma rays, at 898 and 1836 keV. This isotope is well suited for SNO use because the high energy gamma ray is below threshold for the photodisintegration of deuterium and we essentially obtain a gamma ray source without contamination from neutrons. The single gamma near the photodisintegration threshold will be more trigger independent than sources with multiple gammas summing to the same energy.

Previous measurements with acrylic U/Th sources produce neutrons at about the 1/500 level from photodisintegration. This means that one is unable to measure the tail of the Čerenkov spectrum in a clean way.

For ^{88}Y, the 898- and 1836-keV gammas are emitted in coincidence in 91.3% of all decays. In 8% of the decays, only the 1836 is emitted. This ratio will be slightly affected by the source encapsulation and differential attenuation of the gammas. In addition there is a 2734-keV single gamma emitted in 0.72% of all decays. This gamma could obviously photodissociate the deuteron-but we have reduced the number of neutrons by more than factor of 100 compared to our existing U or Th sources. There is also a very small branch emitting 3219-keV gammas in 0.0071% of all decays.

This source will directly permit a determination of the uncertainty in our Monte Carlo simulations of Čerenkov tail events and probe the code robustness at lower energies without the complications of a significant photodisintegration component.

The source deployment vessel was designed, engineered, and manufactured by the Berkeley members of the collaboration. The ^{88}Y source was procured from commercial suppliers. The source was successfully deployed in SNO in February 2003. The source deployment is illustrated in Fig. 1.

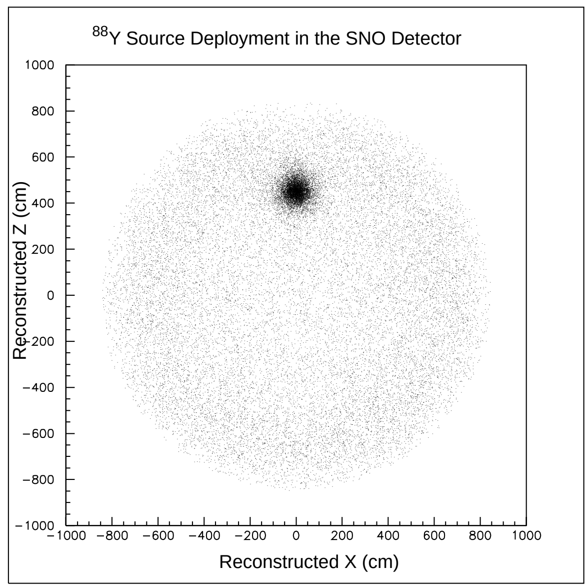

FIG. 1: Reconstructed low energy events from the ^{88}Y source in Z-X projection of the detector. The heavy concentration of events near the top is from the ^{88}Y source, the lower concentration of events is due to backgrounds in the detector, primarily due to U and Th in the water and misreconstructed events from outside the D_2O.

Data from the source are being analyzed and will be included in the upcoming NaCl papers in determining systematics for the low energy Čerenkov tail events.

[1] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **89**, 011301 (2002).